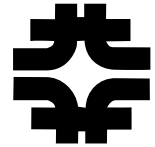


The Fermilab Program and the Projects Under Review by P5

Michael Witherell

P5 meeting

March 26, 2003

The Fermilab Program

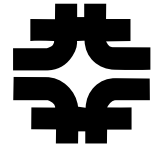
Area of Particle Physics	Fermilab program
• Theoretical Physics, Pheno-menology & Data Analysis	Particle and Astro Theory Lattice QCD
• Electroweak Physics	Tevatron*, LHC**, LC
• Lepton Flavor Physics	NuMI*, MiniBooNE
• Quark Flavor Physics	BTeV, CKM
• Unification Scale Physics	(neutrino masses?)
• Cosmology & Particle Physics	SloanDSS, CDMS*
• Particle-Astrophysics	Auger*

*ongoing construction projects

The breadth of the Fermilab program reflects the US HEP program.

No experiments started since NuMI baselined in 1999.

Outline

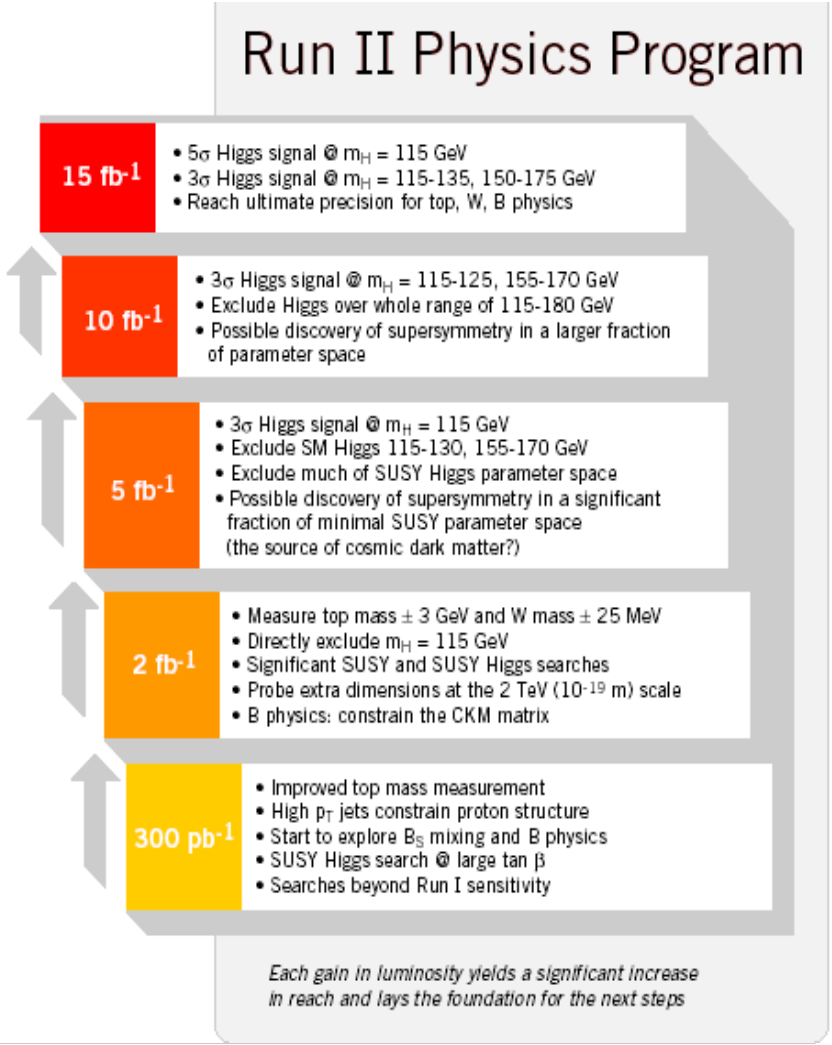


- Operating experiments
- Projects under construction
- Planning the experimental program
- CDF and D0 upgrades
- BTeV and CKM
- Issues for P5
- Summary

The Tevatron Collider Program

Next physics results

- Top measurements
- W measurements
- Searches for supersymmetry, extra dimensions, etc.
- B, B_s, Λ_b, charm physics
- QCD

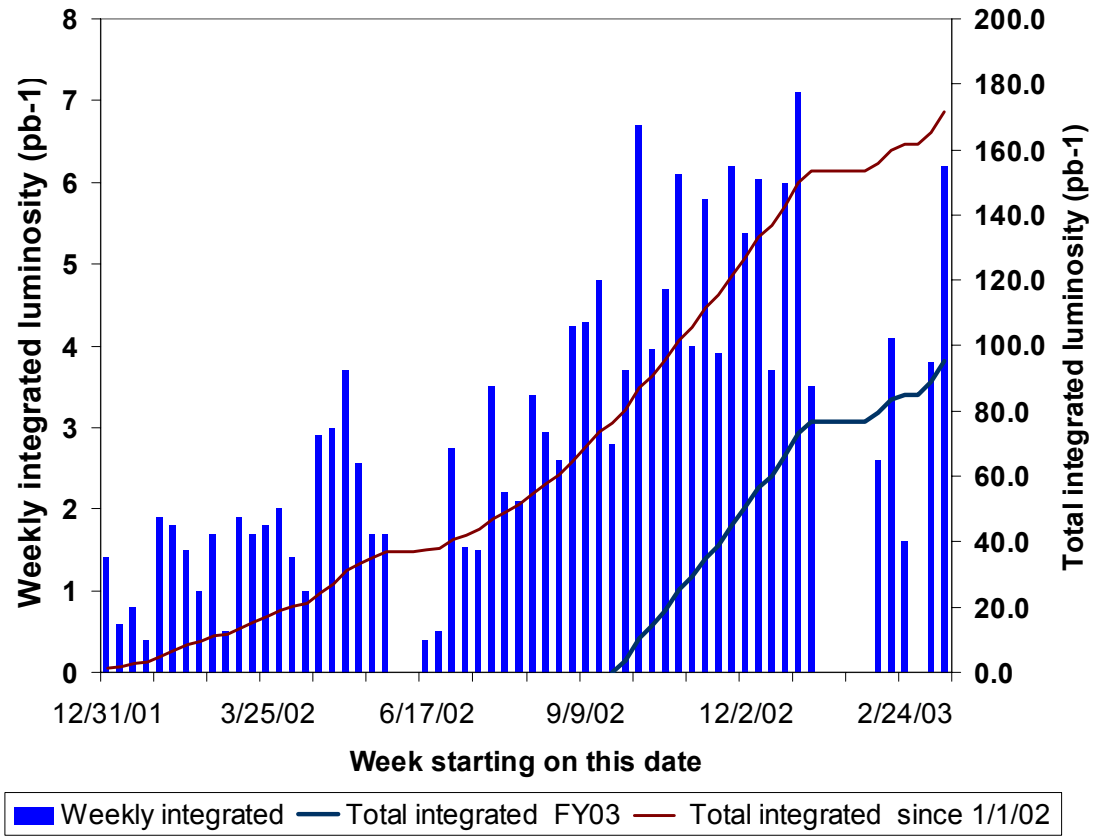


Weekly integrated luminosity

At end of CY 2002

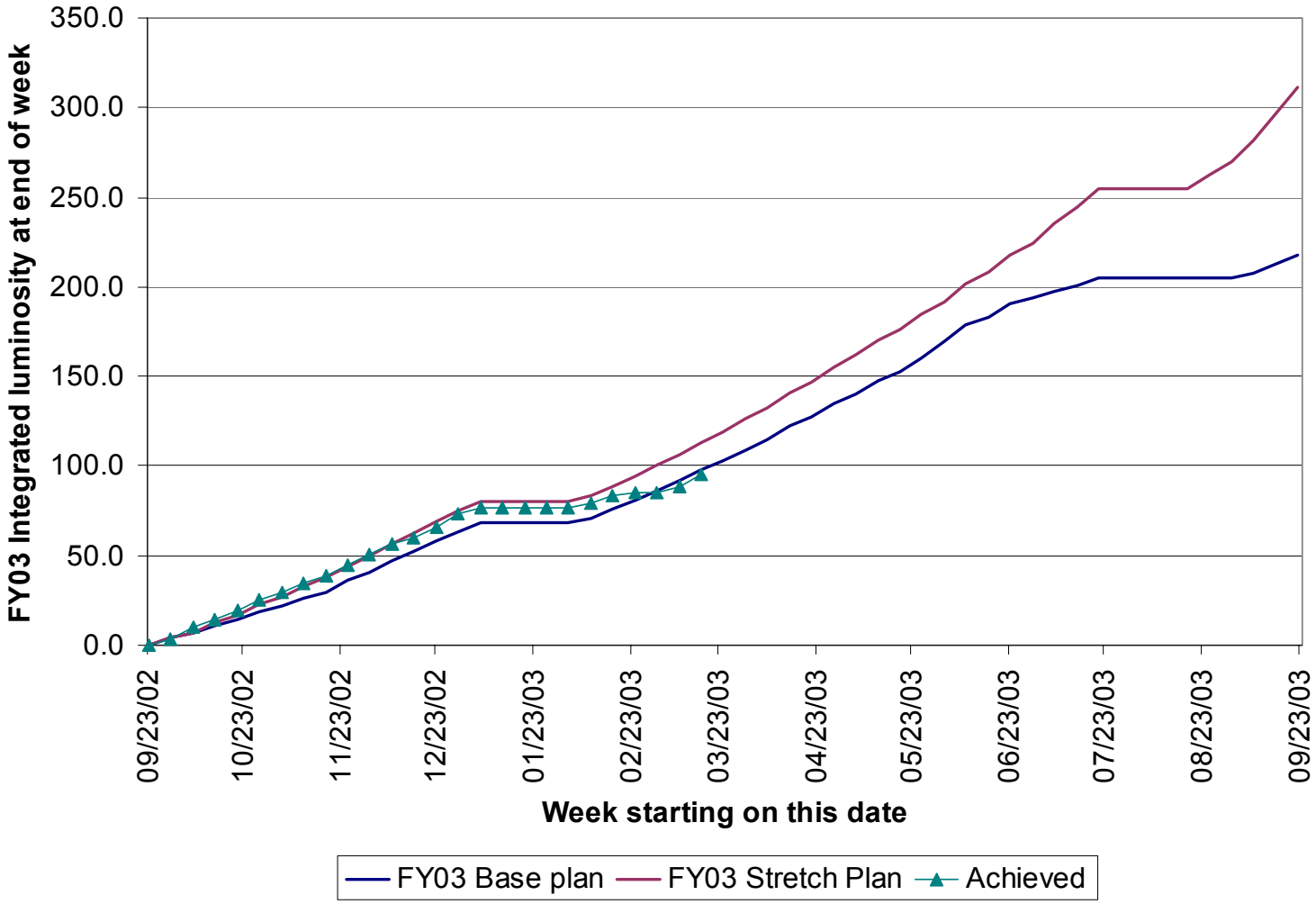
- At start of year
- Best week = 7.1 pb^{-1}
  - 1.4
- Typical week = 5-6 pb^{-1}
  - 1.0
- Best initial luminosity = $3.6x10^{31}cm^{-2}s^{-1}$
  - 1.0

The shutdown was designed to remove at least one bottleneck.

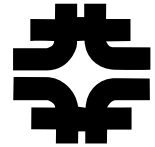


New records on 3/20/03:
Initial luminosity of $4.1x10^{31}cm^{-2}s^{-1}$;
Integrated luminosity 1.7 pb^{-1} in one store

FY 2003 Plan


FY03 Integrated luminosity at end of week
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
09/23/02
10/23/02
11/23/02
12/23/02
01/23/03
02/23/03
03/23/03
04/23/03
05/23/03
06/23/03
07/23/03
08/23/03
09/23/03
Week starting on this date
FY03 Base plan
FY03 Stretch Plan
Achieved

Status of Experiments



DØ

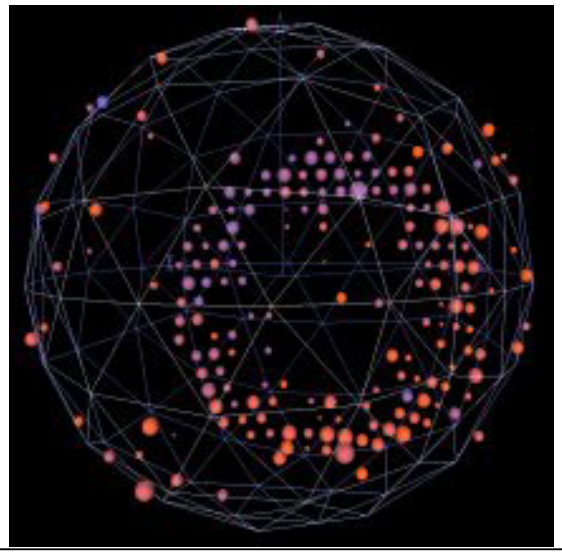
- D0 is taking data with high efficiency and all detector systems in the readout
- Efficiency ~ 90% per run, 85% per week
- March Seminars
  1. Recent results on new phenomena searches at D0
  2. Recent D0 results in B, QCD, Electroweak and Top/Higgs Physics

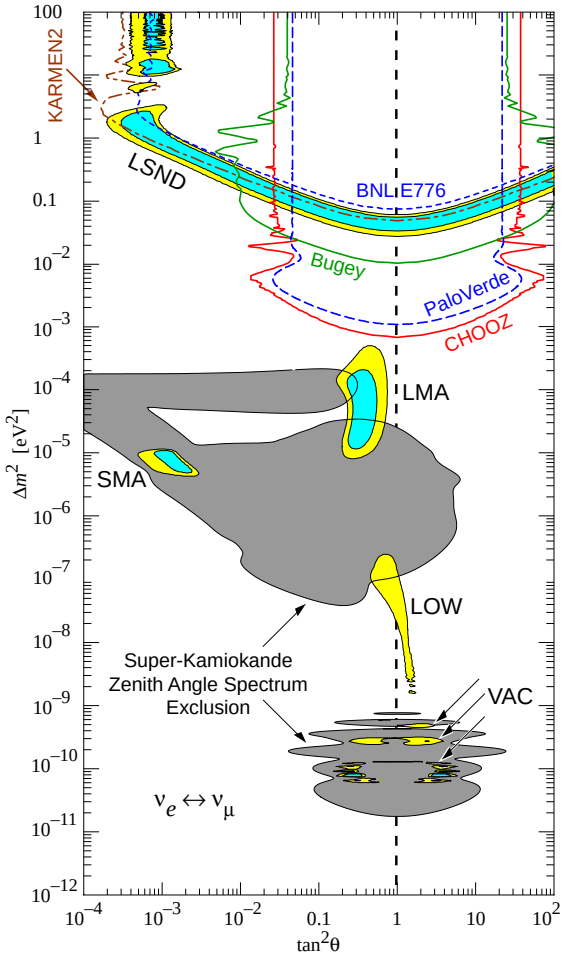
CDF

- CDF is taking data with high efficiency and all detector systems in the readout
- Approaching 90% efficiency
- The silicon detectors are being integrated in a high fraction of the physics data.
- March Seminars
  1. Top, Electroweak, and Exotic Physics in CDF
  2. Charm, B, and QCD Physics in CDF

The Neutrino Program

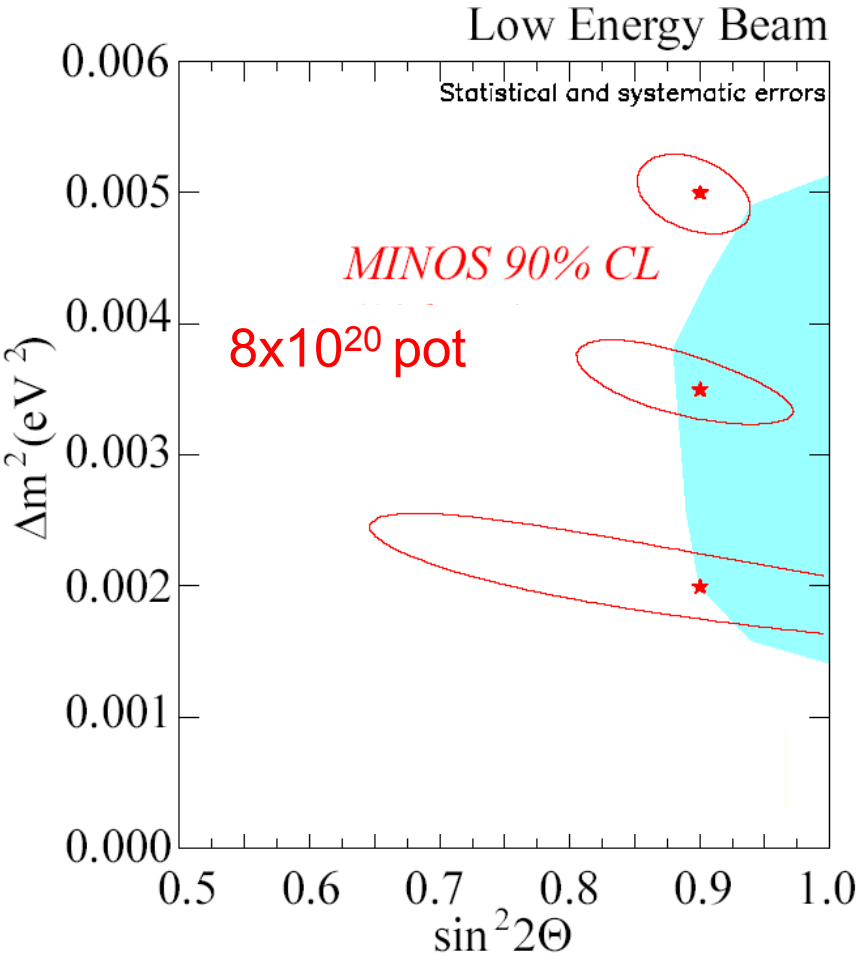
- MiniBooNE
  - is designed to confirm or refute the evidence of a ν_μ–ν_e oscillation at high Δm^2 .
  - The experiment is running well in its first year of operation.
  - Program to lower booster losses has increased flux.



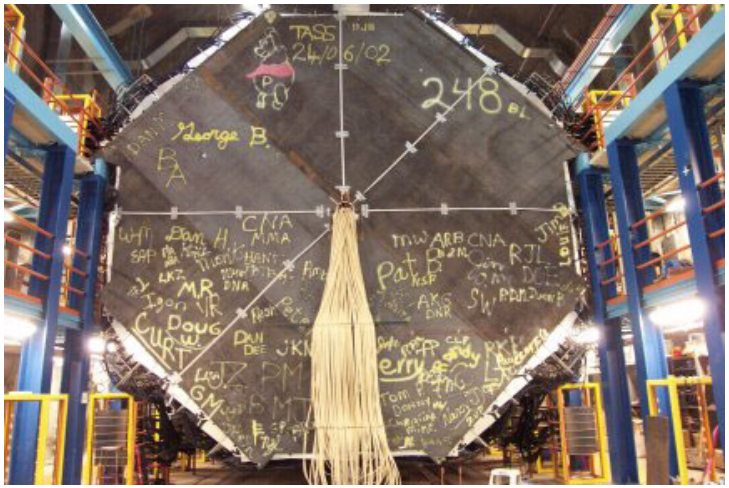


The Neutrino Program

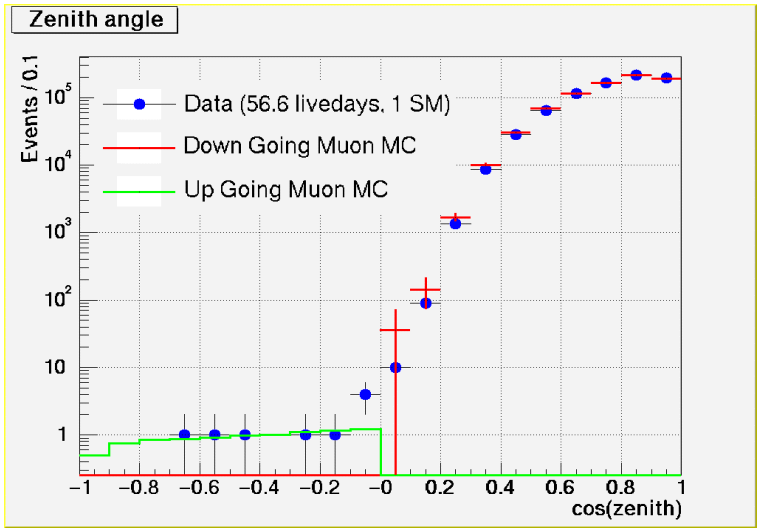
- MINOS
  - will observe and measure the atmospheric neutrino oscillation with high statistics and a controlled source.
  - will start operating early in FY05.
  - uses ν produced by MI protons at L= 740 km.



Status of the NuMI Project



- Good progress on construction
  - Tunnels and Halls contract complete 11/22/02
  - Surface Buildings and Outfitting contract work started 11/1/02
- 432/484 planes of MINOS far detector installed and operating
  - Cosmic ray studies underway
- Heading toward beam in early 2005



Lehman review of NuMI 12/11/02

- "The project's current forecast for DOE Level 0 milestone CD-4 (Begin Operations) is January 19, 2005, which would leave 254 days of float until the baseline date of September 30, 2005. The Committee commended the project for accomplishing all DOE milestones since the last review (two for civil construction and one for NuMI) well ahead of the baseline schedule. However, the Committee is concerned about delays in completing the design of critical technical components. There are no funding issues with the project."

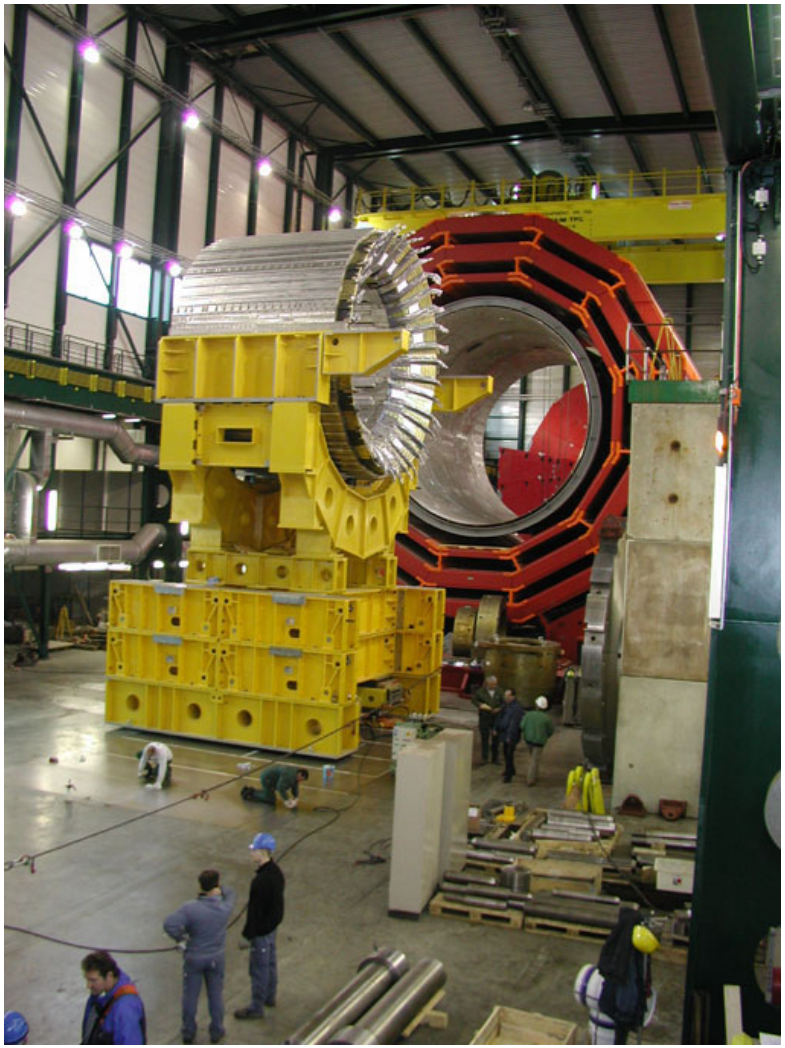
The LHC Program

- US HEP is making a large investment in the LHC accelerator and detectors because of the spectacular opportunities for new discoveries.
- US-LHC accelerator
  - Project >80% complete
    - schedule performance good
    - adequate contingency
  - First Q2 (2 MQXB) is now complete.
  - Planning a US accelerator research effort with BNL, LBNL

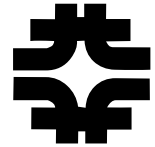
The LHC Program

- US-CMS
  - Project ~80% complete
    - schedule performance good
    - adequate contingency
  - Planning the transition to the CMS research program.
    - CMS software and computing project
    - Maintenance and operations
    - CMS area in Wilson Hall

"The U.S. CMS project is performing well with respect to technical, cost, and schedule goals."
Lehman mini-review 12/13/02



Planning the Future

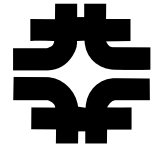


- Planning the future program of Fermilab is inextricably tied to planning the future of HEP.
- We organize our planning in the context of the planning process for US HEP.
  - HEPAP subpanel
  - Facilities plan
  - P5
  - Neutrino task force...

HEP Facilities Summary Table

	Project	Type	Physics	Cost	Scientific Potential	Proposed Facility	State of Readiness	Possible Time Scale
*	**Linear Collider**	Facility	Energy Frontier	$5 – $7 B	Absolutely Central	Absolutely Central	R&D	2015 Operation
*	**LHC Luminosity Upgrade**	Facility	Energy Frontier	$150 M (US Part)	Absolutely Central	Absolutely Central	R&D	2014 Operation
	LHC Energy Upgrade	Facility	Energy Frontier	Unknown	Don't Know Enough Yet	Don't Know Enough Yet	R&D	Decision in Next Decade
	SNAP	Experiment	Cosmology	$400 M – $600 M	Absolutely Central	Absolutely Central	R&D	2009 Launch
*	**BTEV**	Experiment	Quark Physics	$120 M	Important	Important	Ready for Decision on Construction	2008 Operation
*	**CKM**	Experiment	Quark Physics	$100 M	Important	Important	Ready for Decision on Construction	2008 Operation
	Super-B Factory	Facility	Quark Physics	Unknown	Don't Know Enough Yet	Don't Know Enough Yet	R&D	Decision Later This Decade
	Double-Beta Decay	Experiment	Neutrino Physics	$100 M	Absolutely Central	Don't Know Enough Yet	R&D	2005 Prototype
*	**Off-Axis Neutrino Detector**	Experiment	Neutrino Physics	$120 M	Important	Important	Project Engineering and Design	2010 Operation
*	**Neutrino Super Beam**	Facility	Neutrino Physics	$250 – $500 M (Accelerator and Beam Only)	Absolutely Central	Don't Know Enough Yet	Project Engineering and Design	Decision Later This Decade
	Underground Detector	Facility	Neutrino Physics and Proton Decay	$500 M	Absolutely Central	Don't Know Enough Yet	R&D	Decision Later This Decade
*	**Neutrino Factory**	Facility	Neutrino Physics	Unknown	Don't Know Enough Yet	Don't Know Enough Yet	R&D	Decision in Next Decade

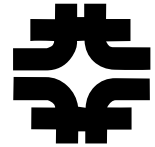
The Physics Advisory Committee



- The Fermilab PAC does the most thorough review of experimental proposals of any review or advisory committee in US HEP.
  - review by a technical committee
  - presentations and questions through several PAC meetings leading up to a presentation meeting in April followed by a weeklong retreat at Aspen
  - carefully written reports produced at the end of each meeting
  - extraordinary dedication of an excellent committee
- I urge you to read the PAC reports at

http://www.fnal.gov/directorate/program_planning/phys_adv_com/PACdates.html

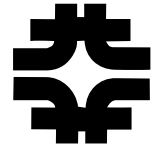
The Physics Advisory Committee



Present membership:
James Alexander, Cornell
James Brau, Oregon
Robert Cousins, UCLA (Chairman)
Takahiko Kondo, KEK
Andrew Lankford, Irvine
Joseph Lykken, Fermilab
Hitoshi Murayama, Berkeley
Michael Peskin, SLAC
Ronald Poling, Minnesota
Natalie Roe, LBNL
Heidi Schellman, Northwestern
Paul Tipton, Rochester
Jim Virdee, CERN

In 6/2000, PAC also included:
Peter Meyers, Princeton (chair)
Giorgio Belletini, Pisa
Leslie Camillieri, CERN
Adam Falk, Johns Hopkins
Nick Hadley, Maryland
Andreas Kronfeld, Fermilab
Frank Merritt, Chicago
Shoji Nagamiya, KEK
Jeffrey Richman, UCSB

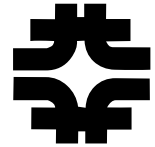
Project Management



- The process for managing projects has worked very well. We have 5 projects now undergoing regular Lehman reviews, 3 of which are >$100M. All of them are making excellent progress, despite the fact that all are very difficult technical projects.

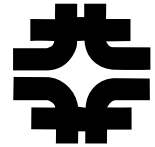
Project	TPC(DOE)	Status
– NuMI	$171 M	78% complete
– US-CMS	$167 M	80% complete
– US-LHC	$110 M	82% complete
– CDF	$28 M	} see Lukens' talk
– D0	$24 M	

Oversight of Project Management



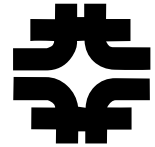
- New DOE regime for oversight of projects came out in 2001.
  - DOE Order 413.1 increased the formality of project oversight.
  - The consequences of budget or schedule problems are more severe.
  - Even a mixed baseline review causes serious problems
- We have improved the way we oversee projects, including the establishment in 2001 of a new Office in the Directorate, led by Ed Temple, that
  - gives boot camp training for managers at the start of a project;
  - collects a terrific set of consultants and conducts a cost, schedule, and management review before the DOE baselining review and subsequent Lehman reviews.
- This process has worked very well. We have 5 projects now undergoing regular Lehman reviews, 3 of which are >$100M. All of them have been doing well, despite the fact that all are difficult technical projects.

Project costs



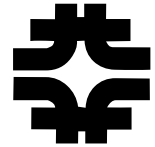
- Project costs are defined to be inclusive.
- They are greater than the marginal cost to the laboratory.
  - Technical personnel and managing scientists working on base funds move to project costs during the project.
  - Indirect costs are charged to the project, but most of those costs do not add to the total G&A burden of the laboratory.

Run II of CDF and D0



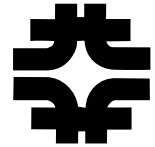
- From now until arrival of the first LHC physics results, CDF and D0 are the only experiments able to address many of the central physics questions of particle physics.
- It is especially important for the field of particle physics that we maintain the only program at the energy frontier over this period.
  - Any discovery would clearly reshape our understanding of particle physics and in addition would help to clarify the energy requirements for the initial phase of the linear collider.
  - Even in the absence of discovery, the Standard Model will be challenged by improved top and W mass measurements combined with results from Higgs searches that could exclude the mass region allowed in the Standard Model.

The physicists are committed to Run II physics.



- About 600 physicists are on each collaboration.
  - Groups are excited about physics prospects and eager to continue the program until the scheduled end.
  - Many groups are managing a transition from CDF/D0 to ATLAS/CMS, as always occurs in our field. Continuous access to physics is important, especially for younger physicists in group.
  - MOUs specify commitments to upgrade projects.
- Demands on collaborations vary with time.
  - 2003: operating experiment; developing reconstruction, calibration, analysis software; getting physics results, building upgrade projects.
  - 2008: operating experiment; getting physics results.

Run IIb Detector Upgrade Projects



12/01 Technical review (J. Pilcher, chair)

4/02 Cost, schedule, management review (E. Temple, chair)

6/02 PAC recommended that we approve it, and we did.

8/02 Joint technical and cost, schedule, management review (Temple and Pilcher)

9/02 DOE baseline review (Lehman)

- no action items
- recommended reduced contingency, which we accepted
- "DOE should move forward expeditiously with CD-1, CD-2, and CD-3a."

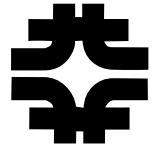
11/02 External Independent Review (Jupiter corporation)

12/02 Energy Systems Acquisition Advisory Board approval

2/03 DOE approval for equipment spending in FY 03

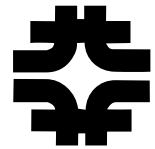
3/03 Sensor and SVX4 orders going out

PAC on CDF/D0 Upgrades 6/2002



- "Maintaining the capabilities of the CDF and D0 detectors throughout the run is also essential for the success of Run II."
- ï ì Run IIb offers the extraordinary opportunity to discover the Higgs boson predicted by the Standard Model or its minimal supersymmetric extensions (MSSM)."
- "Even non-observation of the Higgs in Run IIb would be a result of extreme importance.
  - If the Higgs is not observed, 95% CL exclusion over the mass range required by the electroweak precision data would put the Standard Model in crisis. This is especially so since the Run II measurements of the *W* and top masses may tighten the precision electroweak constraints. If the Higgs is not observed, supersymmetry in the form of the MSSM will be excluded at the 95% CL or better over all but a tiny sliver of its parameter space."

Lehman review report: CDF and D0 Projects 9/2002



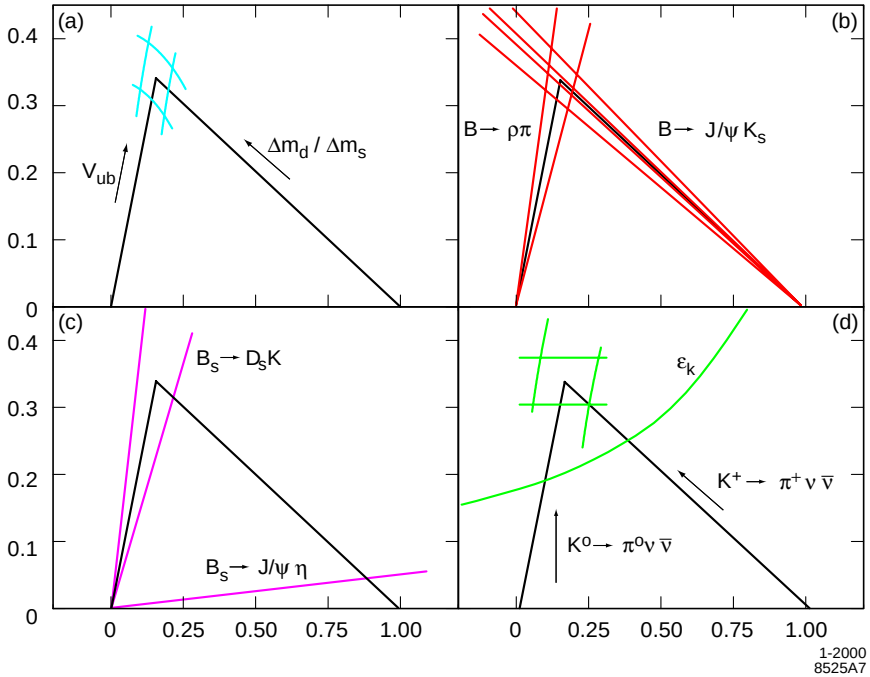
- "The Committee commented on the advanced maturity of the technical design and concluded that the upgrades are technically ready to be baselined."
- "The overall judgment of the Committee is that the Run IIb CDF and D-Zero Detector projects are technically advanced and have good management teams in place. Once the cost and schedule adjustments [reductions in totals] have been made, the Committee recommends that the projects should be baselined."
- "The Committee sees no reason to delay the start of construction."

Quark Flavor Physics

Y. Nir, ICHEP 2002:

- We are leaving the era of hoping for NP alternatives to CKM.
- We are entering the era of looking for NP corrections to CKM.

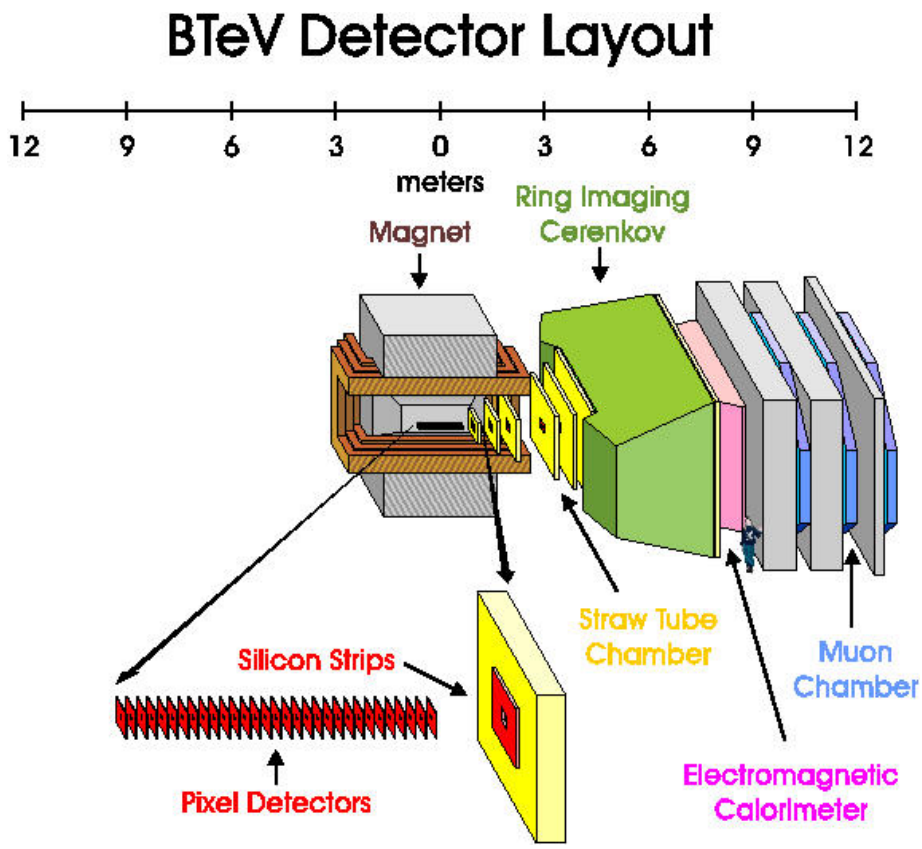
- The experimental goal is to make precise measurements of CKM parameters in channels that are well understood theoretically.
- New physics would show up as an inconsistency between different quark-level diagrams.



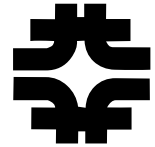
M. Peskin, EPS 99

BTeV

- The next step in B physics requires tagged B_d and B_s samples much larger than any existing B_d samples.
- This can only be done by using efficiently the enormous rate of B production at hadron colliders.
  - Experimental designs required development of new technology, which has finally become available.
- BTeV design makes full use of newly available technology.
  - Pixel vertex detector
  - Vertex trigger at Level 1
  - RICH particle id (forward geometry)
  - Lead tungstate em calorimeter
  - very powerful DAQ system

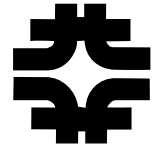


PAC on BTeV 6/2000



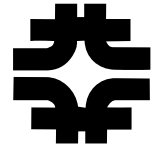
- "The Committee believes that BTeV has the potential to be a central part of an excellent Fermilab physics program in the era of the LHC. With excitement about the science and enthusiasm for the elegant and challenging detector, the Committee unanimously recommends Stage I approval for BTeV."
- "The Committee believes, however, that the program of measuring a comprehensive set of CP asymmetries in the B_d and B_s systems will not be completed by these (existing) experiments. New experiments will be needed at the end of this decade to provide crucial pieces of information. BTeV has the potential to supply these missing pieces of information and could in fact be the definitive experiment that finally clarifies the picture of CP violation."
- "The Committee also concludes that BTeV will have a physics reach for CP violation studies that extends significantly beyond that of current experiments and those that will exist when BTeV runs."

PAC on BTeV 4/2002



- "Indeed, the BTeV collaboration has responded with a descoping plan that the Committee finds to be well thought out and that preserves the key features that motivated the initial approval in 2000. After reviewing the revised proposal and re-evaluating the experiment in light of additional information that has emerged in the last two years, the Committee once again recommends Stage I approval for BTeV."
- "BTeV will have a very broad particle physics program, including charm physics, but the primary motivation is the search for new physics through CP violation. The CP violation in the Standard Model is insufficient to explain the matter-antimatter asymmetry of the universe, so this new physics must exist. In this decade, we have an opportunity to thoroughly probe for it in the B meson systems."
- "BTeV would be unique in having all of the following four key features needed for a definitive mapping of CP violation in the B meson system."

BTeV compared to other B experiments, including proposed

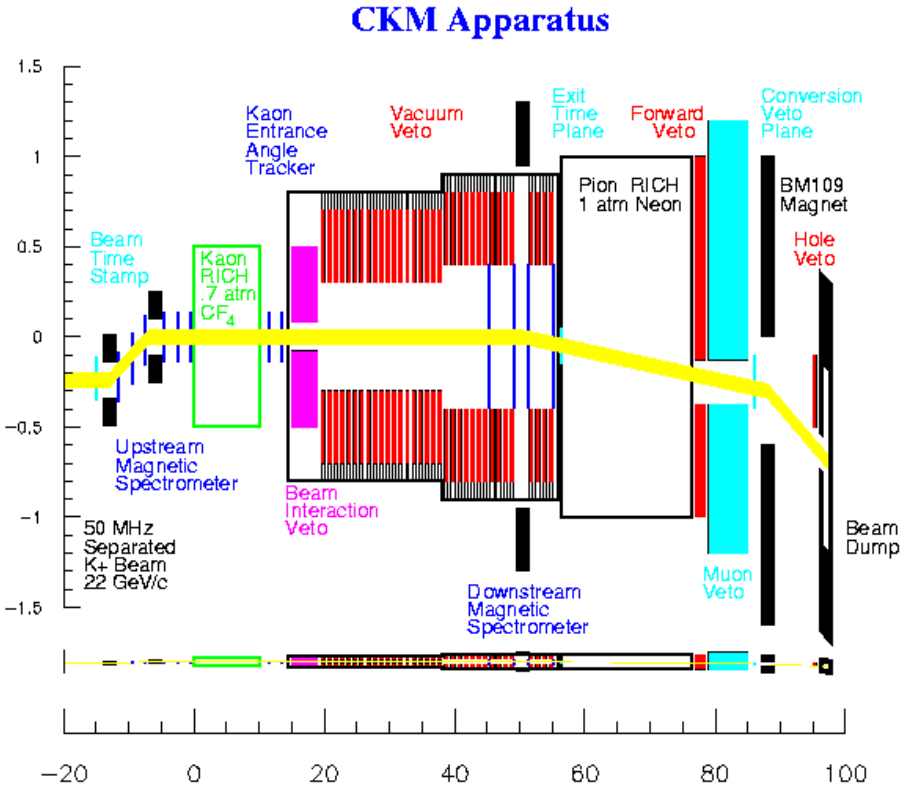


- Upgraded B-factories
  - In important B_d modes, BTeV is comparable to a L=$10^{\sim 36}$ B-factory
  - In B_s modes, B-factories do not compete.
- LHC-b
  - For modes with neutrals, such as $\rho\pi$, the BTeV electromagnetic calorimeter performs like CsI at B-factories.
  - BTeV trigger gives higher rates for all hadronic modes.

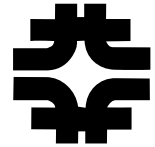
References: See PAC reports and Snowmass 2001.

CKM

- CKM will make it possible to measure $|V_{td}|$ precisely using $K^+ \to \pi^+ \nu\bar{\nu}$.
  - Theoretical uncertainties are ~8%.
  - CKM makes it possible to collect 100 clean events for an experimental error of ~6%.
- CKM is very well designed.
  - Decay in flight in a separated K^+ beam at 22 GeV/c.
  - Redundant high rate detectors and veto systems.



PAC on CKM 6/2001



- "After detailed consideration of the CKM proposal for a precision measurement of the branching ratio of the decay $K^+ \to \pi^+ \nu\bar{\nu}$ and the reports of the technical and cost reviews, the Committee recommends Stage I approval of the experiment."
- "The experiment is based on an innovative technique that will provide redundant measurements of both beam kaons and charged-particle decay products. The redundancies will allow backgrounds to be measured convincingly from the data.
  - The report from the Technical Review of the experiment was favorable, as was the report from the review of the rf-separated beam.
  - The Committee was impressed by the depth of understanding of the relevant issues by the proponents and by their ability to respond rapidly and expertly to questions raised by the Committee and the Review Panel."

Fermilab Long-Range Schedule

Year		2003	2004	2005	2006	2007
Tevatron Collider		CDF & DZero	CDF & DZero	CDF & DZero	CDF & Dzero	BTeV CDF & Dzero
Neutrino Program	B	MiniBoone	MiniBooNE	MiniB / OPEN	OPEN	OPEN
	MI			MINOS	MINOS	MINOS
Meson 120	MT	Test Beam	Test Beam	Test Beam	Test Beam	Test Beam
	MC	E907/MIPP	E907/MIPP	E907/MIPP	OPEN	OPEN

Year		2008	2009	2010	2011	2012
Tevatron Collider		BTeV CDF & DZero	BTeV CDF & DZero	BTeV OPEN	BTeV OPEN	BTeV OPEN
Neutrino Program	B	OPEN	OPEN	OPEN	OPEN	OPEN
	MI	MINOS	MINOS	OPEN	OPEN	OPEN
Meson 120	MT	Test Beam	Test Beam	Test Beam	Test Beam	Test Beam
	MC	E906	E906-DrellYan	E906-DrellYan	E906-DrellYan	OPEN
	ME/P	OPEN	CKM	CKM	CKM	CKM / OPEN

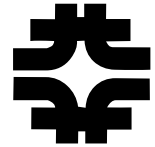
RUN or DATA

STARTUP/COMMISSIONING

INSTALLATION

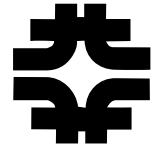
M&D (SHUTDOWN)

Impact on accelerator efforts



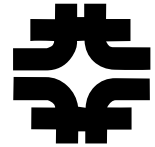
- BTeV and CKM use the accelerator complex as developed by 2008.
  - New IR insertion for BTeV
  - New beam line as part of CKM project
  - Dominant effort is on detectors, not accelerators.
- After 2006, accelerator personnel can be shifted from collider upgrades to work on a future accelerator.

Budget



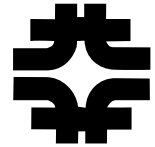
- We have developed a 10-year budget model which
  - operates the accelerator program;
  - funds the collider work and detector upgrades as planned;
  - builds up LHC research program;
  - more than doubles our present LC R&D;
  - completes NuMI and operates MINOS program;
  - builds and installs BTeV in time for 2009 physics;
  - builds and installs CKM in time for physics at end of 2009.
- This total Fermilab base budget is at a peak of $294 M in FY03$
  - model assuming inflation at 4.5% SWF, 2.5% M&S
  - compared with $296 M in FY02, $286 M in FY03
- Budget becomes available. to build toward a new initiative, perhaps 1/4 of the laboratory budget by 2010.

Run II Summary



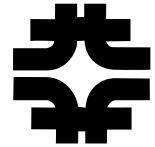
- Fermilab has spent a great deal of time and attention on selecting an optimal experimental program for its accelerators over the next decade.
- CDF and D0 provide great opportunity for discovery.
  - We need to keep the accelerator complex and the detectors operating reliably while increasing luminosity.
  - The upgrade projects are well along.
- A major discovery would advance the field and help choose the energy path of the linear collider.

BTeV and CKM Summary



- BTeV will be the ideal B experiment in the LHC era.
  - It will make possible the most precise measurements of critical parameters using B_s and B_d decays and a broad program of heavy flavor physics.
- CKM will be the ideal K experiment in the LHC era.
  - It will make possible the most precise measurement of V_{td} in K decays and a range of other rare decay studies.
- BTeV, CKM, and the Fermilab neutrino program will provide an excellent experimental program at U.S. accelerators.
  - It makes excellent use of the installed accelerators without major upgrades.
  - The physics return on the investment is high.

US HEP: The experiments operating in 2010



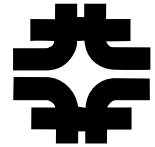
- LHC
  - Atlas and CMS taking data and producing physics.
- Lepton flavor
  - MINOS (mature)
  - Underground experiments abroad
  - MECO(?)
  - NuMI off-axis(?)
- Quark Flavor
  - BaBar, BELLE (?, mature)
  - CKM (?)
  - BTeV (?)
  - KOPIO(?)
- Particle Astrophysics
  - Auger, CDMS, GLAST, Ice Cube, SNAP?
- Linear Collider
  - Status?

• How many experiments among the best in the world will be based at U.S. accelerators? This is very uncertain.

• Would the U.S. support such a program at $800 M?

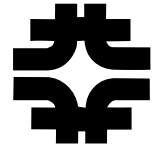
• BTeV and CKM offer the best opportunity for discovery among new experiments using existing U.S. accelerators.

HEPAP Subpanel about P5



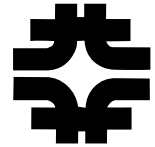
- "The successes in particle physics over the last fifty years were built on a foundation of scientific breadth. An array of experimental strategies and techniques were used to reach our intellectual goals. For the future, we need to continue that strategy by crafting a program that utilizes a variety of scientific approaches."
- "P5 should meet on a regular basis and serve as the guardian of the roadmap. It should continually review the program, update the roadmap, look to the future and identify problems and opportunities. The panel should advise HEPAP and the agencies on the proper prioritization of mid-scale projects that have a significant impact on the particle physics program."

Establishing the standard for P5



- The process and results in this first round should set a standard for the future operation of P5 that will stand up well.
- You serve as a check that the Laboratory and its committees did a deep, thorough review of these projects and used a high threshold for approval.
- After the exercise of the facilities plan, you are in a position to place the scientific potential of these experiments per $ invested in the context of future as well as present experiments.

Summary I

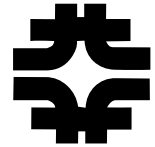


I encourage you to say the following in your report:

- Endorse the evaluation of all these experiments by the Laboratory and the PAC.
  - State that the standard for approval of these experiments is higher than in the past, because of budget realities.

- Recommend completion of the CDF and D0 detector projects on the appointed schedule.
- Recommend that BTeV be approved for construction on the schedule proposed by the Laboratory, assuming a successful baseline review.
  - State that BTeV will be the best experiment at the end of the decade in the very important area of B physics and will be an excellent part of the world program of particle physics.

Summary II



- Recommend that CKM be approved for construction on the earliest schedule that is compatible with funding availability, as worked out by the Laboratory and DOE-HEP.
  - State that CKM will be the best experiment at the end of the decade in the very important area of K physics and will be an excellent part of the world program of particle physics.

In conclusion, state that:

- This plan optimizes the scientific output of US HEP.
- The experiments make excellent use of the existing accelerator complex.
- These evaluations and recommendations are made in the context of the world program and with knowledge of the experiments that might compete for this physics in the future.